

III. Some Electrical Experiments, chiefly regarding the Repulsive Force of Electrical Bodies; communicated in a Letter from Granville Wheler, Esq; F. R. S. to Cromwell Mortimer, M. D. R. S. Secr.

S I R,

THE following Experiments I made in the Autumn of the Year 1732. and repeated them to Mr. Grey the following Summer, when he came into the Country. I had then Thoughts of communicating them to you through his Hands, to whom they owe their Being, and drew them up with a Letter to him prefixed: But, unwilling to be an Author, I deferred the Communication from time to time, till the second Summer came, when I was informed, that Mr. Dufay had written a Letter to his Grace the Duke of Richmond, dated Dec. 27. 1733.* wherein he takes Notice of the same Solution of the Repulsive Force, a Copy of which Letter I received the September following, inclosed in one from Mr. Grey. All Thoughts of publishing them were then laid aside, but meeting some time since with a fuller Account of them in the Memoirs of the Academy of Sciences for the Year 1735. by which it appeared Mr. Dufay's Experiments were not the same with my own, and having since received the Commands of our worthy President to communicate them, I take the Liberty at last of sending them to you, as I intended they should have passed through Mr. Grey's

* *Philosophical Transactions*, № 431. p. 258.

Hands,

Hands, if Mr. *Dufay* had not appeared upon the same Subject, in three Propositions, and a few Corollaries. I am, Sir, with a very great Regard,

Otteſden-Place,
Jan. 17. 1737-8.

*Your much obliged,
humble Servant,*

Gravv. Wheler.

P R O P O S I T I O N I.

Bodies made Electrical, by communicating with an Electrical Body excited by Friction, are in a State of Repulsion with regard to such excited Bodies.

E X P E R I M E N T I.

I hung a fine white Thread by a Loop, to an horizontal blue Silk Line, about four Feet long, tied at each End, and at about a Foot distance from it, placed a Glass Tube two Feet and a half long nearly, and one Inch and quarter Diameter, fixed in the Centre of a circular Piece of Wood supported upon three brass Skrews, so that the Tube and pendulous Thread were parallel to each other. The Tube being rubbed, the Thread was attracted and repelled Seven or Eight times (in very good Weather, I have observed it move to and from the Tube Twelve times, at above one Foot Distance). I then tied a Piece of new smooth Packthread to the Top of the Tube, and to the Loop of the Thread hanging down as before, and again excited the Tube: The Thread, without coming once towards the Tube, went into and con-

tinued in a State of Repulsion; but if I only touched the communicating Packthread with my Finger, the white Thread immediately hastened to the Tube: And upon hanging another long Piece of Packthread, which reached the Ground, to the communicating Packthread, and again rubbing the Tube, the pendulous white Thread was so far from going into a State of Repulsion, that it became attracted to the Tube, and continued so, without shewing the least Tendency to a State of Repulsion, as long as the Virtue of the Tube lasted.

E X P E R I M E N T II.

I tied a Piece of small Cane about sixteen Inches long, and one fourth of an Inch Diameter at one End, and a little more at the other, at right Angles to the Top of my Tube, fixed in the same Pedestal as before, and making unequal Arms with it; and at the End of the larger Arm, a Piece of Stick traversly, about six Inches long, so as it might slide backwards and forwards to and from the Tube: This moveable short Stick at one End supported a very fine white Thread, at the other a very fine blue Silk, by which means we had now a Silk and a Thread at the same time hanging parallel to the Tube. The Thread, after the Tube was rubbed, first was attracted, but then immediately repelled, and continued a considerable time in a State of Repulsion; but upon tying to the End of the shorter Arm of Cane, a Piece of long Packthread, which reached down upon the Table, and rubbing the Tube again, the Thread continued in a State of Attraction, without being once repelled during the whole Virtue of the Tube,

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as in the preceding Experiment. Yet the Silk, whether the long Packthread was added or not to the shorter Arm of the Cane, continued constantly attracted towards the Tube; but upon putting a short Silk only six Inches long, in the same Circumstances, it would, after some time rubbing the Tube, turn into a State of Repulsion, the upper Part first bending from the Tube, and the lower Part towards it, the upper Bending still increasing till the Whole was repelled; and, which is remarkable, the upper Part or Bending, upon the Approach of the Finger, or any Body not impregnated with Electrical *Effluvia*, flying towards it, and the under Part or Bending rather seeming to fly from it, till the Whole was saturated, and in a State of Repulsion with regard to the Tube, and then any Part of it would come to the Finger, or any other Body, not made Electrical. It is proper to add here one more Difference remarkable between the Thread and Silk: The Thread in a State of Repulsion touched with the Finger, would immediately fly towards the Tube; but the Silk in the same State, after touching several times, still continued in a State of Repulsion, and would not be attracted till squeezed from Top to Bottom between the Finger and Thumb, once, and sometimes two or three times. And farther, the Thread would immediately turn again into a State of Repulsion, whereas the Silk, after the Violence committed by the Thumb and Finger, being attracted to the Tube, would not without a good deal of rubbing the Tube, be repelled again.

N. B. The Silk was untwisted, and about one fourth part of the Thickness made use of.

C O R O L L A R Y I.

From the different State of the pendulous Silk and Threads at the same time under the same Circumstances, the former being attracted while the latter is repelled, it follows, that a mere Vibration of the Parts of the Tube is not sufficient to account for the Electrical *Phenomena*; which appears farther from the two contrary States continuing some time, and from the same Piece of Silk being at once part in a State of Repulsion, part in a State of Attraction.

C O R O L L A R Y II.

That some Bodies immediately receive and immediately part with the Electric *Effluvia*, but that others are some time before they receive it, or receive enough of it; and when they have received enough of it, part with it more unwillingly.

C O R O L L A R Y III.

That any light Body, as a Feather, after touching or nearly approaching the Tube, must fly from it: Upon Contact or a near Approach, it saturates itself with the Electric *Effluvia*, and by this means becomes itself Electrical (as is plain from its coming to all other Bodies too large to come to it); and consequently, from the foregoing Experiments, is in a State of Repulsion with regard to the Tube. As soon as it touches any other Body, it loses its acquired Electricity, and therefore may be attracted as at first.

P R O P O S I T I O N II.

Two or more Bodies made electrical by communicating with an Electrical Body, excited by Friction, are in a State of Repulsion with regard to one another; or Bodies made electrical by Communication, repel one another.

E X P E R I M E N T I.

I suspended two Pieces of white Thread, each about one Foot long, by Loops, upon an horizontal blue silk Line four Feet long, about half an Inch asunder from each other; and upon holding the excited Tube over them at a little Distance, the two Threads immediately receded from each other considerably at the Bottom. I then removed one of the Threads, and held the Tube over the other, in the same manner as before. The single Thread was not observed to move to either Side; consequently the moving of the Threads side-ways was occasioned neither by the Attraction of the cross Line, nor that of the Tube, nor by the Frame of Wood, to which the cross Line was tied at each End, but only by their Action upon each other.

I then added a third String, at the same Distance from the second, that the second was from the first, and upon holding the excited Tube over the middle one, at the same Distance from the cross Silk I did before, if the Strings continued in the same Plane, the middle one stood still, and the String on each side of it receded considerably at the bottom Part, which in this Case must necessarily happen upon a
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Supposition, that they repel one another equally ; for the two contrary Forces of the outer Threads destroy each other, and consequently the middle one must remain quiet ; but there was nothing to hinder the middle one from repelling the two outer on each hand sideways. If, as it often happened, the three pendulous Threads did not remain in the same Plane, they then all receded from one another equally, and formed nearly a triangular Prism ; the three Threads being the three Edges, or rather a triangular Pyramid with the Top cut off.

Upon suspending four Threads at the same Distance as before from one another, if they continued in the same Plane, they all parted, but the two outermost more from their Neighbours, than the two in the middle from each other.

If they moved out of the Plane they were first in, they formed two Prisms, each extreme with the two in the middle forming one, or rather a Parallelopiped, less at Top than at Bottom.

When five Strings were suspended, either the middlemost continued Stationary when the Plane was not altered, or if it was, they formed three Prisms.

E X P E R I M E N T II.

I afterwards placed two cross blue Silks, of the same Length as before, about half an Inch asunder from one another horizontally, and tied at each End ; and upon each of these, at different times, hung two, three, four, and five Threads, at the same Distances as before, when every thing succeeded, as it ought to have done, upon a Supposition of their mutually repelling one another.

E X P E R I M E N T III.

To each of the Ends of two Threads, suspended as at first, a Feather being tied, the two Feathers manifestly receded from each other: And when three Threads had each a Feather at their Extremities, the middlemost became Stationary, and the two outer went off on each hand.

E X P E R I M E N T IV.

I suspended afterwards two, three, four and five blue silk Strings by Loops, upon one cross blue Silk, and found the several Experiments succeed in the same manner as in Threads; except that they remained a longer time before they appeared in a State of Repulsion, receded from one another more slowly, and continued much longer in the repulsive State, after the Tube was removed.

E X P E R I M E N T V.

This done, I made several Experiments, by mixing Silks of different Colours, and Silks and Threads of different Colours, and suspended them by Turns upon Silks of different Colours, whence arose several different *Phænomena*, which I shall not take Notice of here; but I must not omit mentioning, that upon suspending two black Silks at the before-mentioned Distances from each other, upon a scarlet cross Silk, they did not only open and recede from each other at the Bottom considerably, but when the Tube was held under, ran or jump'd away from each other, to the very Ends of the cross red Silk that supported them, taking two, three, or more Jumps from each other.

I observed the same of two white Silks suspended upon red Silk, but think they did not move away so briskly as the Black.

E X P E R I M E N T VI.

I tried whether Threads hanging parallel, as above, from a cross blue silk Line, and joined with one or more transverse Threads, so that the perpendicular Threads remained nearly parallel, would mutually repel when the Tube was held over them; they seemed to repel each other full as strongly as before. When they were joined by only one cross Thread towards the Top, the lower Parts separated considerably; when joined by two cross Threads, one towards the Top, and one towards the Bottom, they separated both in the middle Parts between the two cross Threads, and at their lower Ends under the second or lowest cross Thread. When several were tied together at the Top and Bottom, and about a Foot long, not by transverse Threads, but in a Knot at each End, they all bellied out from one another, describing a Figure generated by an Ellipsis, revolved about its greater Axis; approaching nearer to a Sphere, the stronger the repulsive Force was. And, though it was only a necessary Consequence, I could not without some Pleasure observe the Knot at the Bottom, as the Strings swelled out, sensibly rising up. I could scarce forbear imagining my Bundle of Silks, a Bundle of muscular Fibres.

E X P E R I M E N T VII.

I suspended two brass and afterwards two iron Wires upon a cross blue Silk, in the same manner
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as the Threads and Silks before-mentioned, and found the Experiments succeed as in Threads of the same Number, except that they did not recede so far from one another, which must necessarily follow from their greater Weight.

N. B. These Experiments were made sometimes with the Tube held over, sometimes held under the cross Line; but they generally succeeded best when the Tube was held under the Extremities of the pendulous Wires, which in this Case separated much farther, and kept their repulsive Force much longer.

E X P E R I M E N T VIII.

I must not omit here, that I hung up two Fragments of Barometer Tubes, each about a Foot long, by blue silk Lines going through each, so that they hung parallel, horizontal, at equal Heights, and about one quarter of an Inch asunder; upon holding the excited Tube above and under them, they manifestly receded from each other.

I suspended the same Fragments of Tubes by blue silk Lines of equal Length, from a cross blue Silk in a perpendicular Posture, each having a little red Sealing-wax at the upper End, to hinder the Strings from slipping off: The excited Tube being brought near them, they receded manifestly, especially at the lower Ends; the Distance from one another, when at Rest, being about a quarter of an Inch.

C O R O L L A R Y I.

From the repulsive State of the pendulous Threads tied transversly with two or more Threads, and bend-

ing out from each other, where at Liberty, it follows that all the Threads of a Table-cloth, or other large Piece of Linen, when made Electrical, (as has been often done all over) have a Desire to fly from each other; and consequently, was the repulsive Force strong enough, the Whole would be dissolved, or torn in Pieces. A short Thread of black Silk, by repeated Applications of the Tube, I have separated into its smallest Fibres: Whence is suggested more plainly, than from any other known Experiment, a Reason for the Dissolution of Bodies in their respective Menstruums, *viz.* That the Particles of the Solvend having imbibed the Particles of the Menstruum, so as to be saturated with them, the saturated Particles become repulsive of each other, separate, and fly to Pieces.

And hence, perhaps, arises a Reason, why Particles of Bodies specifically heavier than the Menstruums in which they are dissolved, are, after the Dissolution and Dispersion, suspended all over the Menstruum, *viz.* That they repel each other. Attraction is insufficient; for Parts attracted equally in all Directions, are, in Effect, not attracted at all, and the Imperfection of the Fluid will not do; for if this occasioned the Suspension, striking or jogging the Vessel would make them subside.

C O R O L L A R Y II.

Hence we plainly see how Heat may divide the Particles of Water with greater or less Force, in Proportion to the Degree of Saturation, and throw them into the Air; where they may continue to ascend, if at the same time they are divided, they are expanded into little Shells or Bubbles, of a Diameter large enough

enough to be specifically lighter than the lower Air, as the great *Halley* has sagaciously conjectured. Or if the upper Parts of the Air, as being less saturated than the lower Parts, may be able to draw them upwards, till the Excess of Weight, which is constantly increasing, is equal to the Excess of Attraction.

P R O P O S I T I O N III.

Bodies, made Electrical by rubbing, do themselves repel one another, or the electrical excited Bodies themselves repel one another.

E X P E R I M E N T I.

The two Fragments of Tubes before-mentioned *, being suspended horizontally, and in a Posture parallel to each other, I held in one Hand, and with the other rubbed some time; then gently letting them go so as to be at Rest, I could plainly perceive them recede from each other towards that End which had not been taken hold of.

But as upon repeated Trials I found it difficult to make this Experiment succeed unexceptionably, the Tubes generally having some reciprocating Motion of their own, after quitting the Hand, I made use of the following Method.

I suspended a single little Tube about a Foot long, by a long blue silk Line, perpendicularly, and upon a Table placed my great Tube fixed in a Stand as before, excited each alternately, two or three times;

* Prop. II. Exper. VIII.

then

then gently moved the Tube with the Stand it was fixed in, near the suspended little one: The little Tube manifestly receded so much, that a cross blue silk Line stretched horizontally at about an Inch Distance on the opposite Side, would sometimes, upon the first Approach of the great Tube, be touched by it.

E X P E R I M E N T II.

Three scarlet Silks, pendulous each by Loops from a cross silk Line, and close together, being rubbed downwards two or three times, between the Finger and Thumb, shewed a considerable repulsive Force with regard to each other, forming themselves immediately into a triangular Pyramid, and continuing in this State of Separation some time, and which shews their Attraction at the same time, with regard to other Bodies not excited, coming to them when brought near them.

I observed the same repulsive Force in three yellow and three green Silks, under the same Circumstances, and excited in the same manner, but not in so great a Degree as in Scarlet. In Blue the repulsive Force was scarce discernible after several times rubbing.

S C H O L I U M.

The Revd Dr. *Stephen Hales*, in his 12th Article of his 13th Experiment, in his second Volume of *Statical Essays*, observes, “ That if a Piece of one of the *Bronchia* or Gills of the *Muscle-Shell-Fish*, be cut off, and put into a small concave Glass, with three or four Drops of its Liquor, and be then placed under a double Microscope, the Blood may be

" be seen greatly agitated in the fine Vessels; and at
 " the cut Edge of the Piece of Gill, may with great
 " Pleasure be seen many Blood-globules, repelled
 " from the cut Orifices of the Blood-vessels, and
 " attracted by other adjoining Vessels; also other
 " Globules rolling round their Centre, and repelling
 " each other; whence (as he says) it is plain, that
 " Bodies, by brisk rubbing and twirling about, may
 " acquire, in a watry Fluid, both attractive and re-
 " pulsive Virtue or Electricity."

From our last Experiments we are led to think, that the Globules of the Blood, if by Friction they acquire an electrical attractive Virtue, must of necessity repel one another; and that Electricity is not so properly called an attractive and repulsive Virtue, as a Virtue attractive of those Bodies that are not attractive themselves, and repulsive of those that are; and that this repulsive Force of the electrical Blood-globules, excited by Friction, as they flow in their Channels (and particularly in the small ones, and perhaps more so in those of the Lungs, where the refrigerating Power of the Air may assist, as Dr. *Hales* has observed); this repulsive Force of the Blood-globules, I say, may be the great Cause that hinders the Blood from coagulating as it circulates; may be the great Cause of the constant Perspiration in an healthy State, and of the Increase of it, *cæteris paribus*, in Proportion as the Velocity and Friction of the Blood increases.

If these things are so, the Necessity of Exercise appears more plainly than ever, in order to keep the Body in an healthy State, as we may observe here the very Steps that Nature makes use of to free herself from her Suppressions.

Granv. Wheeler.